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solar & wind power, ltd.

Photovoltaic Systems

Technology and Economics

June 16th , 2010

DOE Conference

Presented by Geoff Greenfield

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SOLAR & WIND POWER

Today we will:

- Review today’s solar technology options
- Discuss system sizing, purchasing and installation
- Discuss Energy and Economics in today’s environment
- Review selected case studies

About Third Sun

We are the region's leading solar company,
offering "turn-key" design-build solar solutions to commercial, government, utility and residential customers.

Our solar powered offices in Athens Ohio

Third Sun was founded in 2000 and provides complete engineering, procurement and construction services to clients primarily in the Midwest.


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HomeWrap
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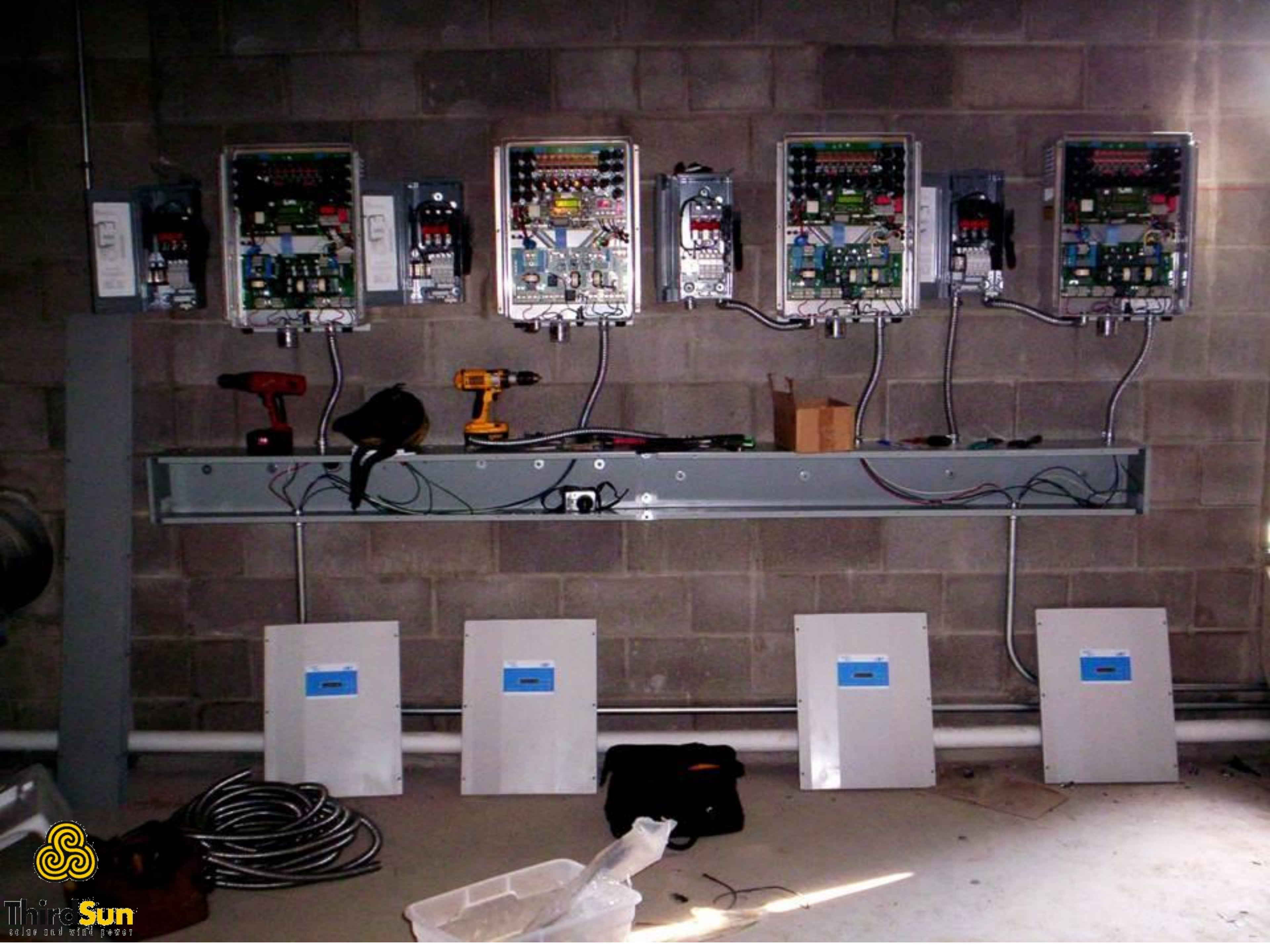
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Geoff and Ben work on Twenhofel West Array


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Will you treat “green energy”
as a challenge or an opportunity?
Does it even work in my area?

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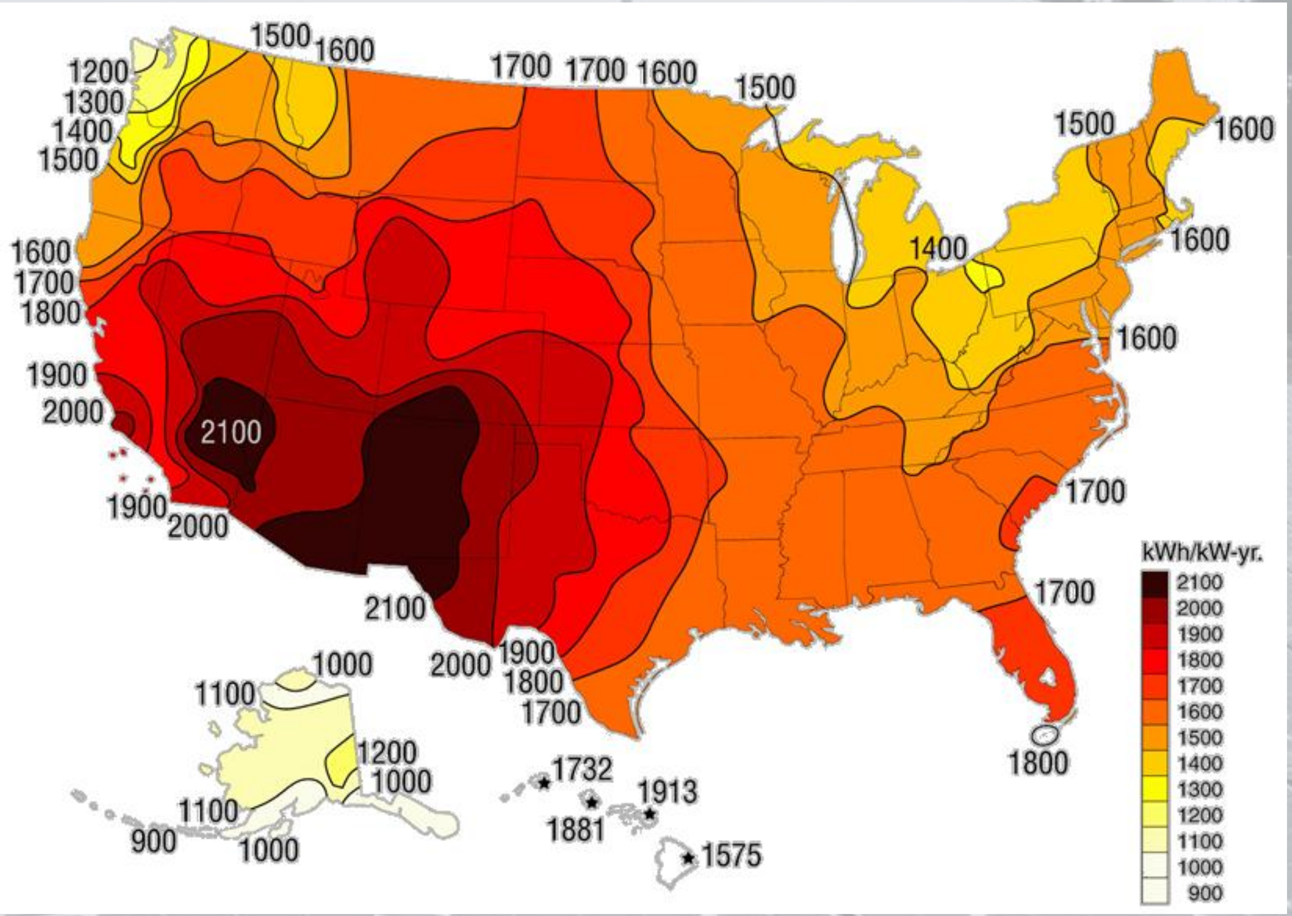

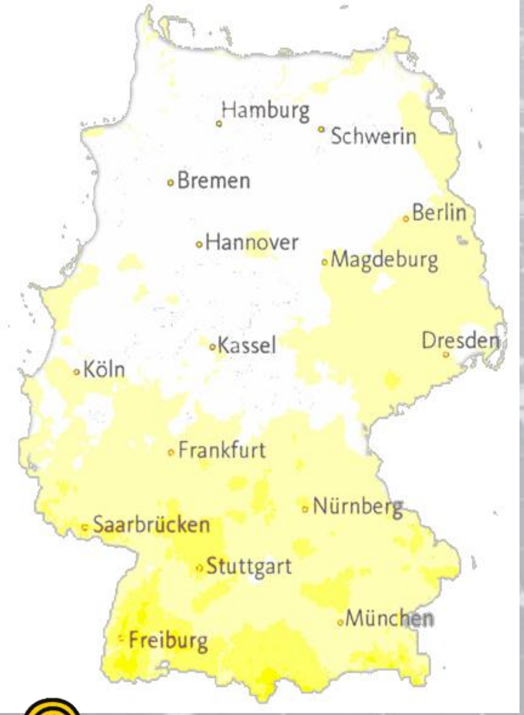

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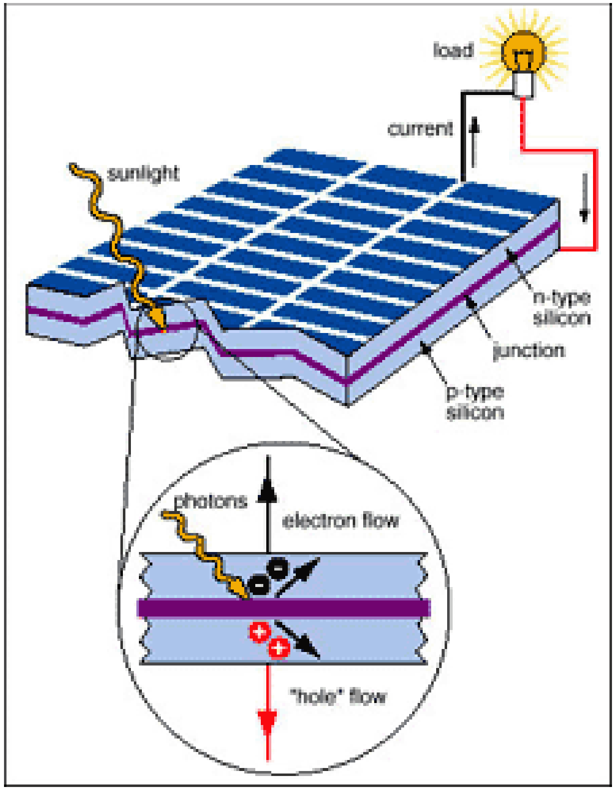
Solar Technology

How Solar Electricity works



Sunlight excites electrons in specially treated silicon material.

Movement of electrons causes electrical current.

Current is harnessed, combined with current from other cells and put to use.

25 Yr warranty – 30-50? Year design life – very slight degradation (<.08%/Yr.)

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The Solar Array

- Roof, ground, wall or integrated mounting.
- No shade allowed!
- Axis: South (15 deg +/-)
- Pitch: 26 degrees (flat-lat)
- Variety of colors, styles and shapes – can be invisible or a design element

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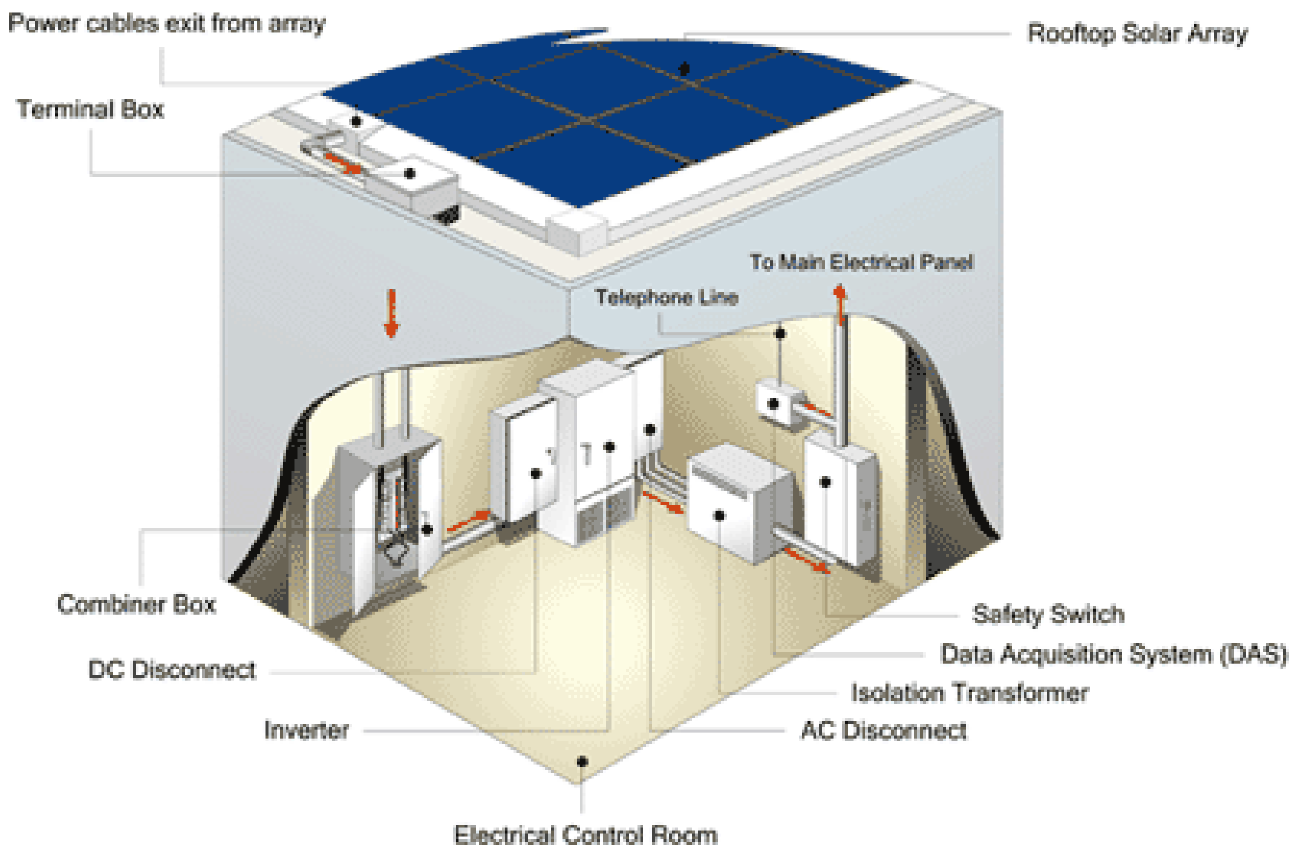
“net-metering” allows the solar AND the utility to meet the buildings needs *together.* This Innovation is the best of both worlds, avoiding battery cost and inefficiency, providing tremendous design flexibility as production that exceeds the buildings internal use is sent backward through the utility meter for credits used at night and on cloudy days.



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Crystalline (poly or Mono)

- Proven longevity and performance
- Typically requires 1 SF per 10w (SunPower/Sanyo= 16) watts of panel.
- Weight is typically 2-4 Lbs per SF (or 4-8 with ballast on flat roof).
- Not a commodity – important brand differences

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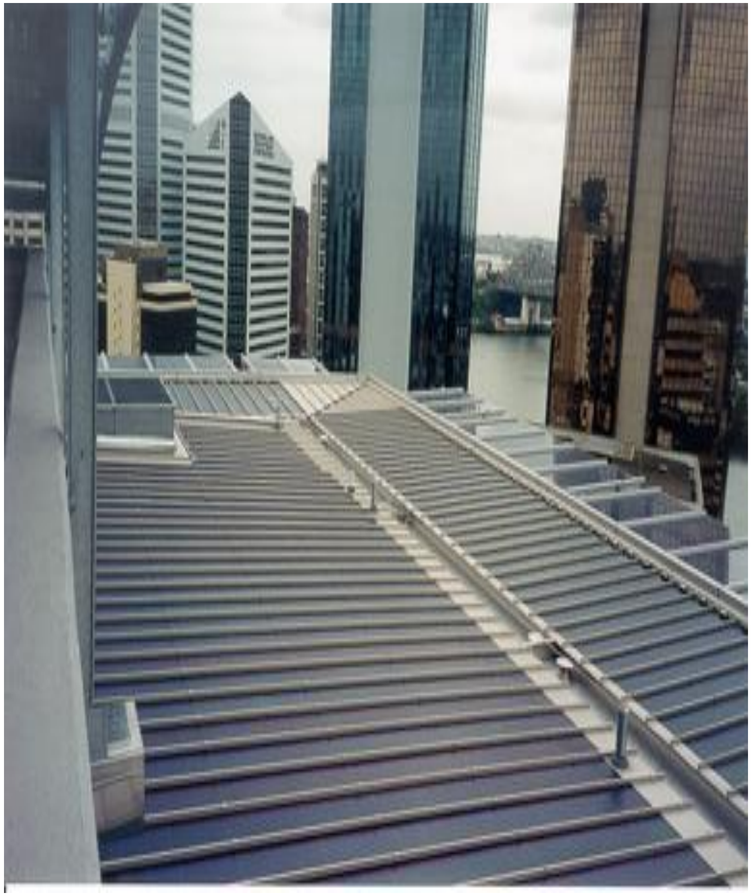
Thin Film



- Many up and coming utility focused solutions (First Solar)
- Uni-Solar PVL series ("peel and seal") is market leader
- Slight (+/-5%) productivity advantage "per watt" (BUT may be offset by angle on flat roof)
- Lowest weight per SF (1/3 lb per SF)
- Very low energy density (<5 W/SF)
- Unique aesthetics

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Racking solutions

- Rails (UniRac, power tube).
- Manufactured system – wind uplift is the design driver.
- Attachment detail important – flashed penetrations VS roof sealant.
- SS metal roof uses S-5! Clamp (pay attention to pan connection detail).
- Pole mount or large ground mount systems.

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For flat roofs: Ballasted Racking Systems

- **SunPower T10**
  - 10-13% tilt maximizes energy production and minimizes shading
  - Patented design installs quickly reducing the installed cost of solar
  - No roof penetration required, withstands winds up to 120 MPH
  - Self grounding attachment (UL Listed)
  - Walkways and easy individual panel removal increase roof accessibility

PV can be an architectural feature

high visibility project has enhanced company image

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Carports and Canopies

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Large scale arrays: lean and no concrete

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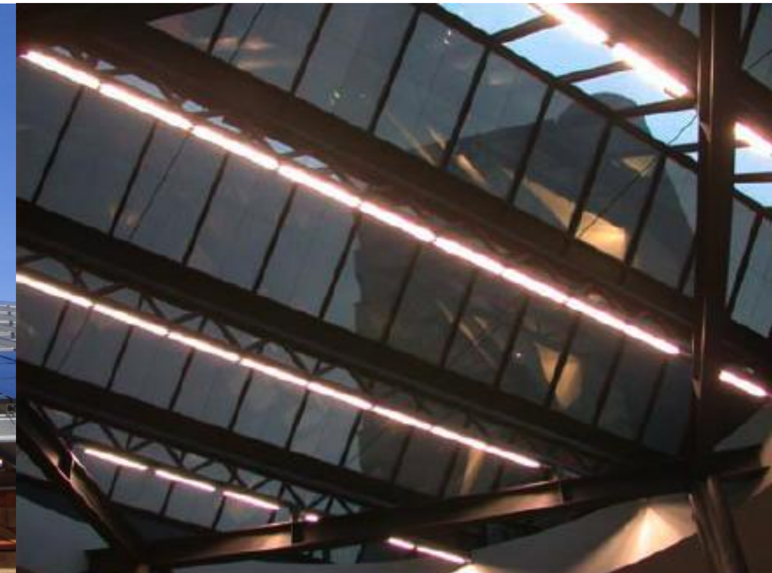
Building Integrated PV (BIPV)



To track or not to track?

- Case by case cost benefit calculation…
- (+) 20-35% gain (mostly summer)
- (-) Complexity, maintenance
- (-) Energy density (shading and spacing of multiple arrays)
- (-) Cost:
  - $3/w VS $1/w for racking, $13/w VS $11/w installed

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Power Processing Equipment

- The DC output of the solar array must be converted to Utility quality AC power
- Addresses safety issues
- Typically battery free
- Modular or centralized
- Located indoors or outdoors

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Monitoring and Reporting

- Built in or additional kWh meter always!
- Remote data reporting – Fat Spaniel or other
- Alerts, performance ratios and actual irradiance a plus.
- Kiosks, web sites and “bragging rights”>

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Project Management considerations

Economics and Incentives

Typical design steps:

• Clarify and understand stakeholder's motivation and goals. This often includes stakeholder education (as well as countering misinformation and out of date assumptions).

• There are typically three design drivers:

    • Available un-shaded roof space

    • Power production goals (kWh, LEED%, modeling)

    • Budget (after subsidies, may be driven by projected tax appetite) .

• Start with the roof and shrink (or expand onto the ground) if needed.

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Purchasing and installation

- Potentially long lead times – (immature supply chain)
- Permitting now includes utility interconnection application
- Coordination with roofer and electrician essential – define scope of work, warranty issues ahead of time. (Avoid finger pointing… and “wasn’t my job” syndrome.)
- Inverter/panel design process (electrical and mechanical/aesthetic) often makes performance specification difficult.
- Commissioning issues: performance monitoring and a variable resource (the sun).
- Design build VS traditional bid/spec: who is the expert?

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How to evaluate?

- Energy density (is kW per SF = efficiency?)
- Production (or is kWh per $ = efficiency?)
- Productivity (or is it kW per labor hour?)
- Warranty (and strength of backing company)
- Power tolerance (+/-10% or +/- 3%)

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Energy Production vs. Demand

Solar Production	**kWh/year per sq. ft.**
Crystalline Modules	10 - 20
Thin Film Modules	6 - 12
Building's Energy Demand	
Average Commercial Building in Midwest	10 - 20

- For multi-story buildings there is rarely enough roof space to offset more than 50% of electric needs.
- Pick the right strategy and technology to fit your project goals!
- Remember Energy Efficiency!

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Sizing rules of thumb:

1 kW DC of solar = 60-100 SF (panel efficiency and racking type)

1 kW DC of solar = $7,000-$4,500 *economies of scale!*

1 kW DC of solar = 900-1,400 kWh/year *location!*

1 kW DC = 1 SREC/ year

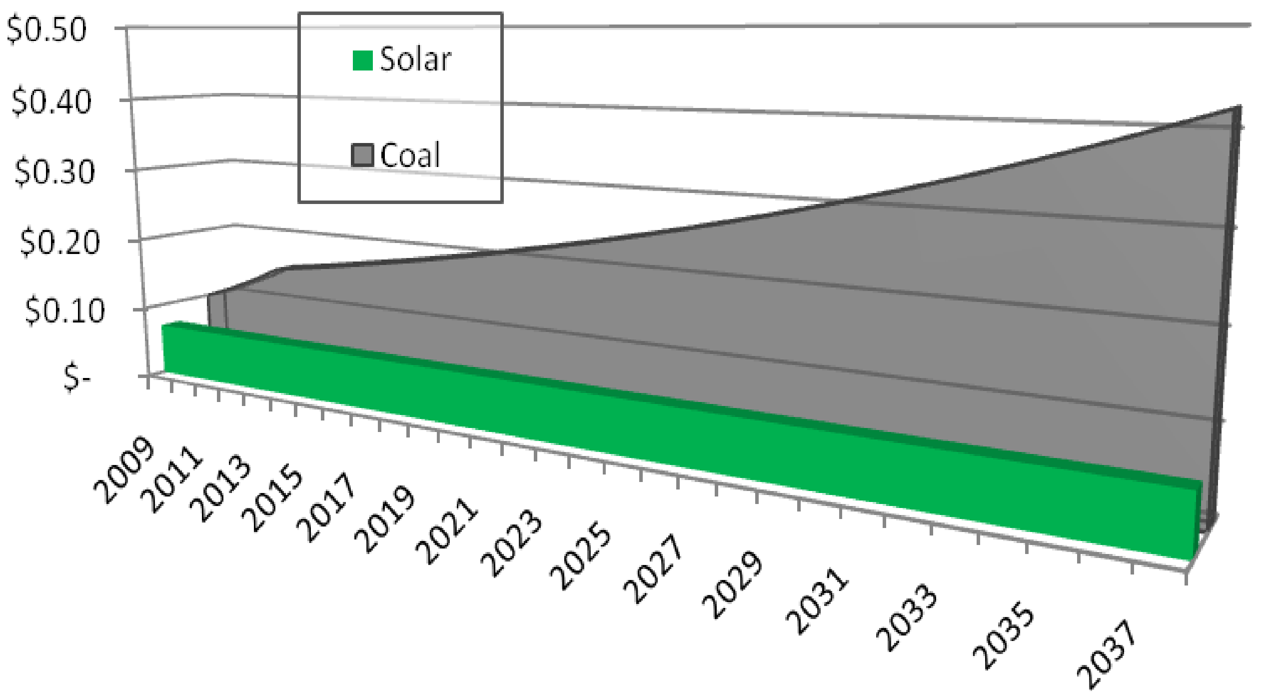
Economics of PV

PV Investment is a hedge against future energy prices

Cost of fuel = zero

Result: Total cost of 30 years of energy is locked in on day 1!

Economics depend on expected brown energy cost and inflation

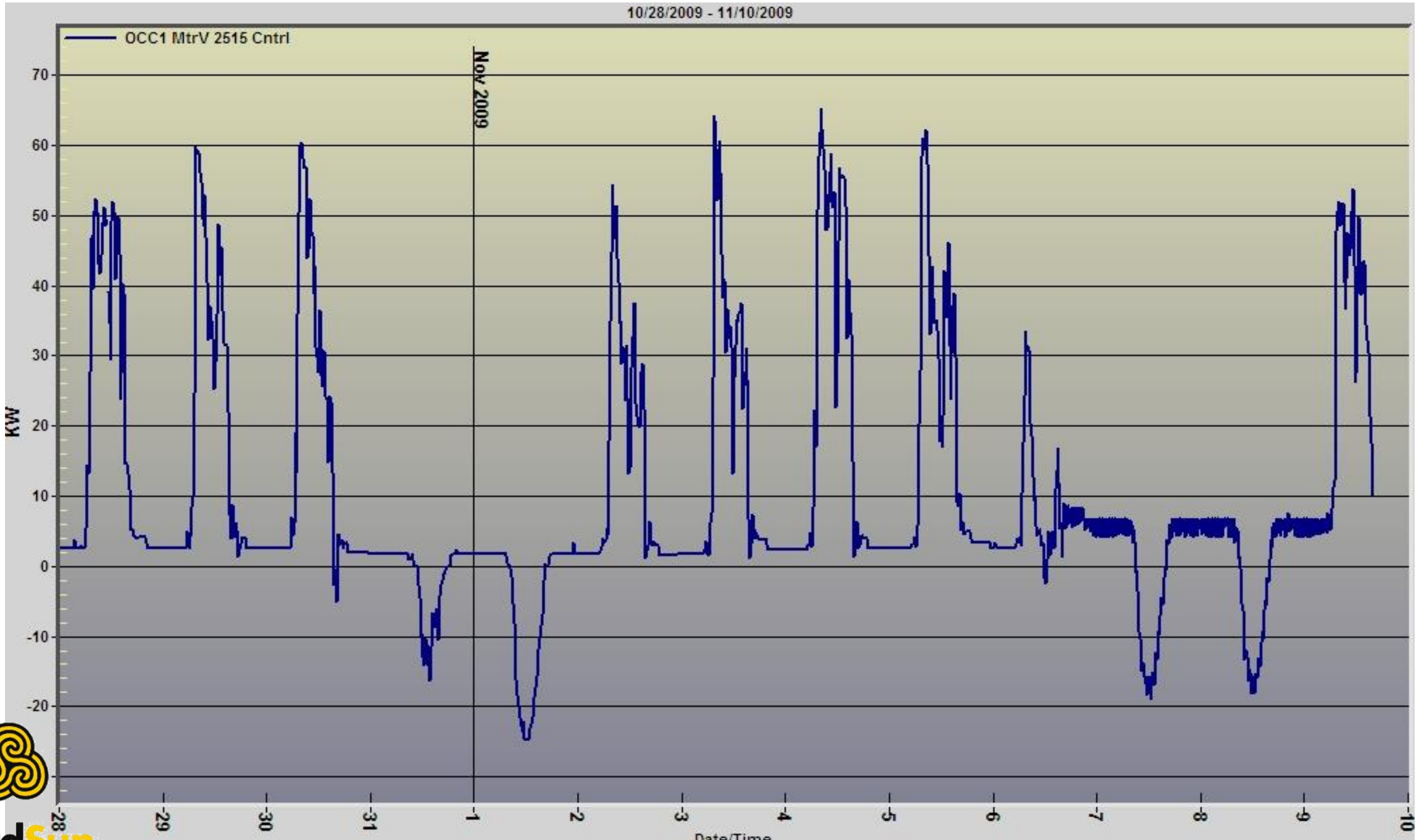


Greater Cincinnati Water Works

43.92 kW ballasted system
Occupies 3,845 square feet
Produces 48,500 kWh per year

Bi-directional power flow and Net Metering

Commercial (light manufacturing) building with 45kW PV



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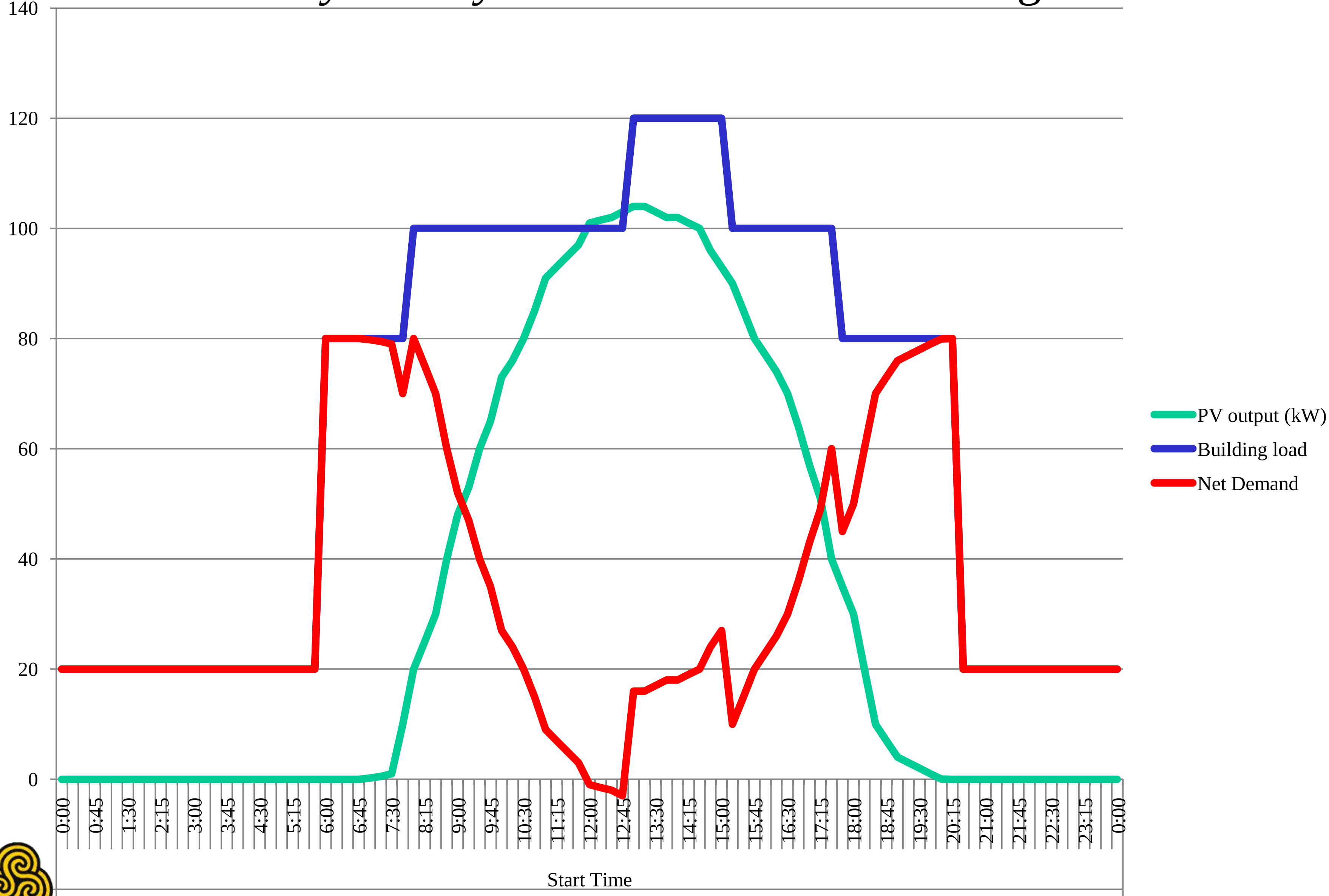
PV *May or May Not* Reduce Demand Charges



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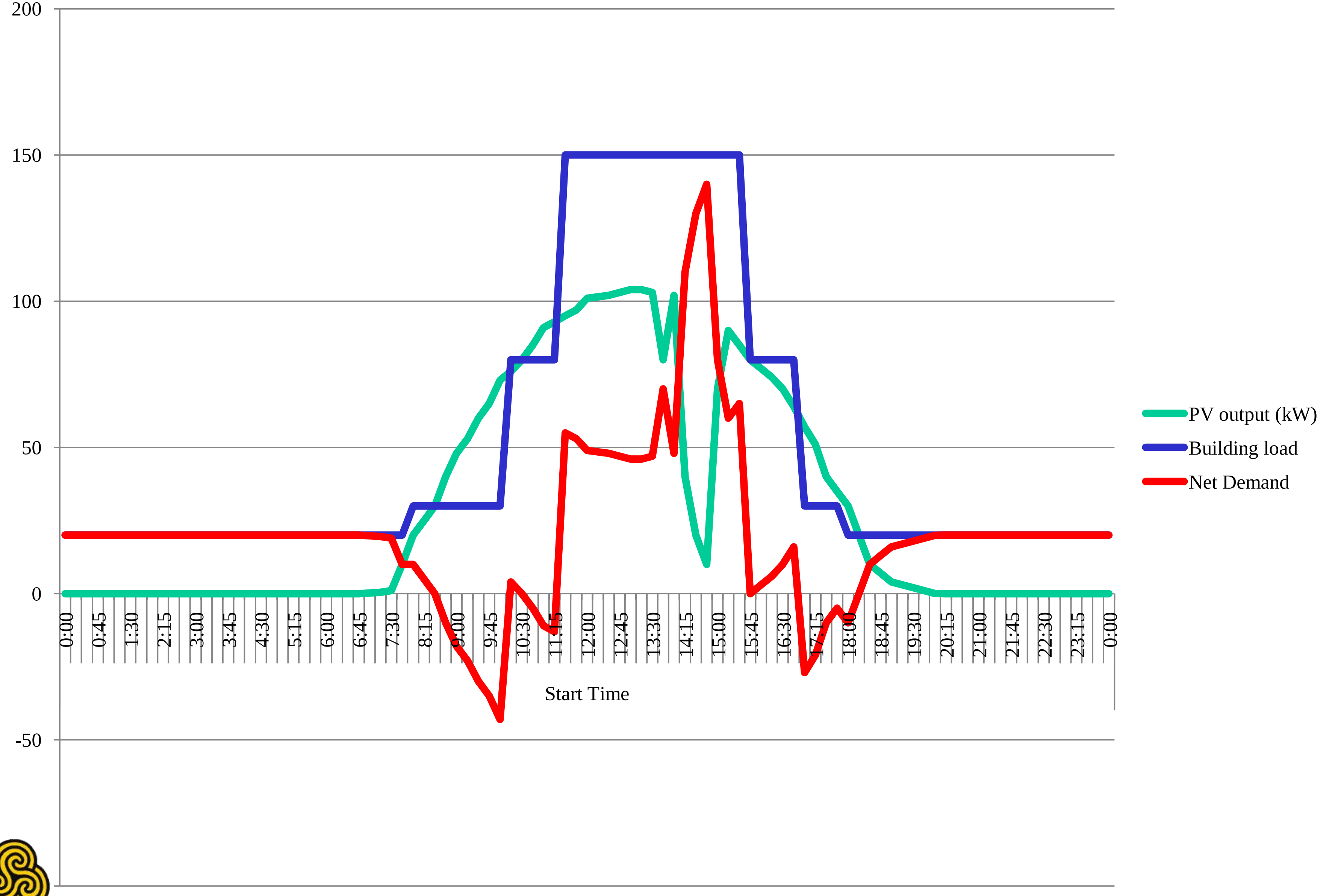

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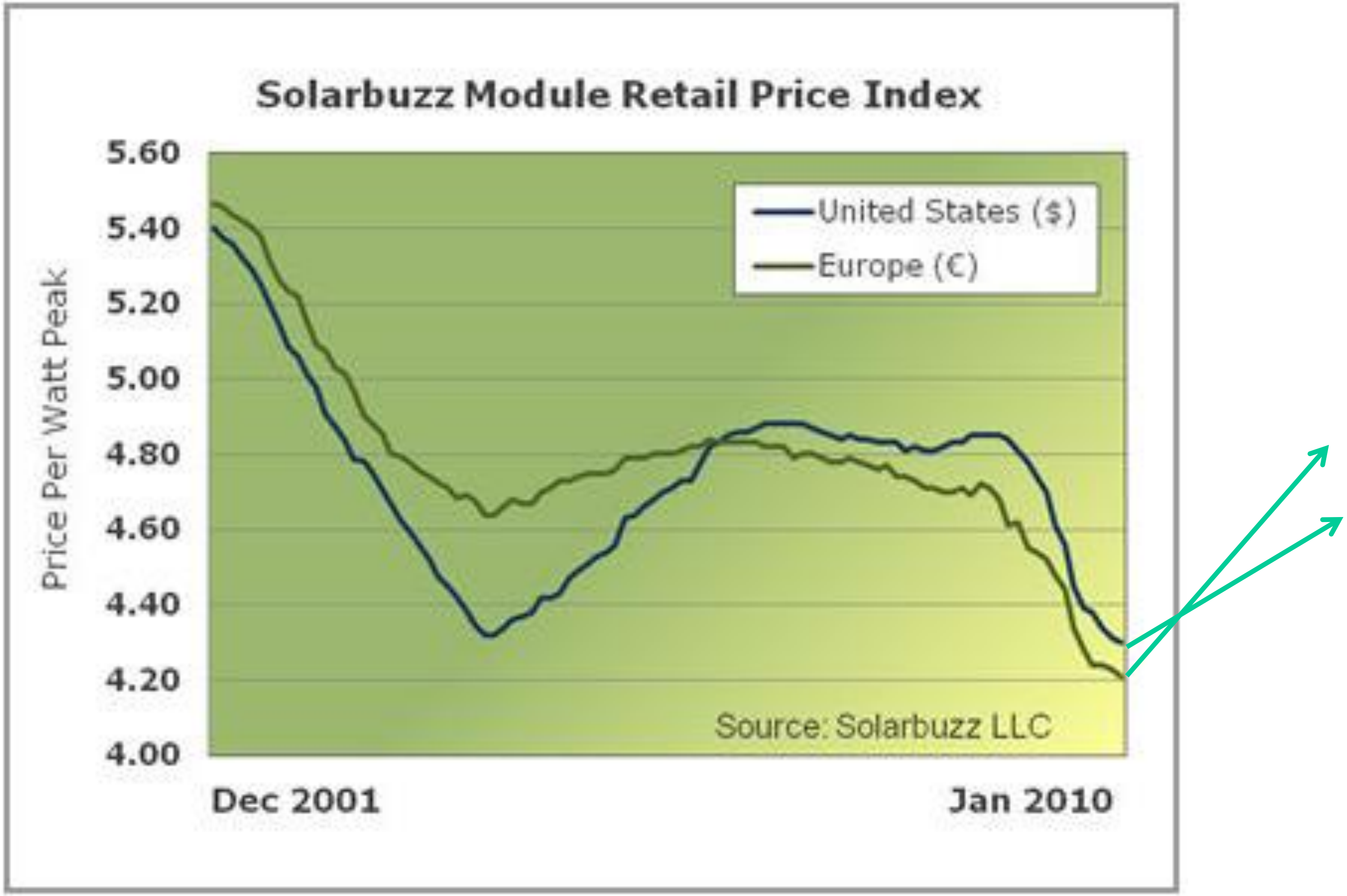
Solar Prices



RE Financial Incentives

Purchase Incentive - based on system size or cost

- Federal tax credit
- State rebates & tax credits
- Local rebates & tax credits

Production Incentive - based on energy production

- Production tax credits
- REC sales
- Reduced utility costs

Comprehensive Incentive Guide: www.dsireusa.org

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Federal Tax Credit

•30% of actual project costs. Can be taken over multiple years.

•Available as cash grant for projects “started” in 2010

•Recently extended through 2017, and applied to TOTAL cost
(what counts toward total depends on your tax attorney)

•Accelerated depreciation schedule (MACRS). Worth another +/- 20-35% depending on tax situation.

•You need to consult with your accountants and tax expert etc…

•Schools/non-profits and units of government don’t pay taxes.

(One of the advantages of a PPA model)

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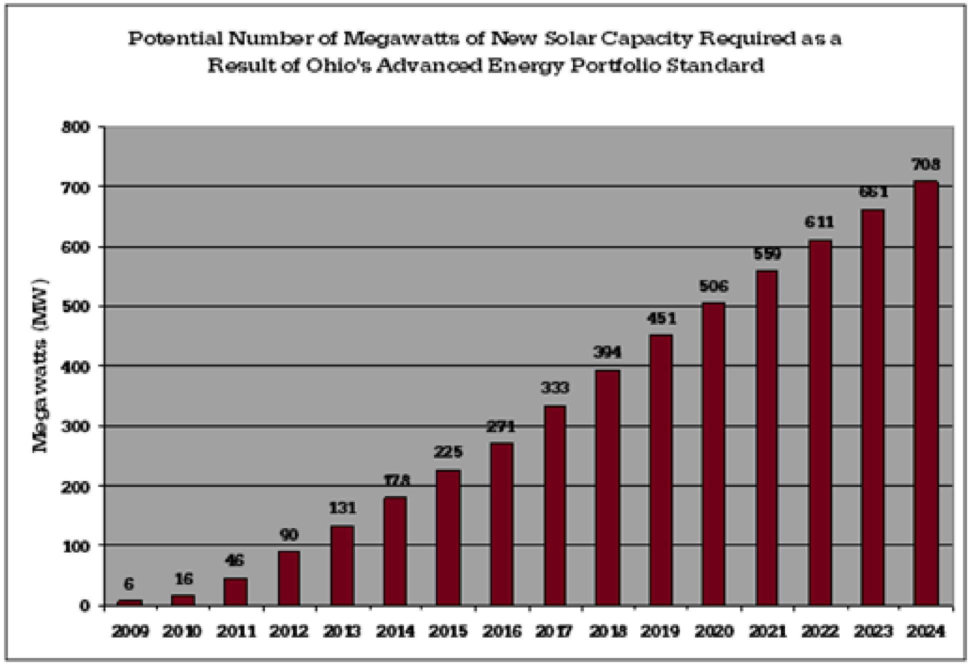
SB 221 and Ohio's Advanced Energy Portfolio Standard

•Renewable Portfolio Standards (RPS): a popular mechanism used by 24 states.

• Mandates utilities include 12.5% Renewable Energy by 2025. There is a Solar "carve out" of .5% (the rest will probably come from be wind and biogas etc).

•Alternative Compliance Payment (ACP) and annual milestones create a market for S-RECs (Solar Renewable Energy Credits). This separates energy and environmental attributes, allowing an economic benefit from both.



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SREC Sales

Alternative Compliance Payment

year	%	ACP
2009	.004	$ 450
2010	.01	$ 400
2011	.03	$ 400
2012	.06	$ 350
2013	.09	$ 350
2014	.12	$ 300
2015	.15	$ 300
2016	.18	$ 250
2017	.22	$ 250
2018	.26	$ 200
2019	.3	$ 200
2020	.34	$ 150
2021	.38	$ 150
2022	.42	$ 100
2023	.46	$ 100
2024	.5	$ 50

- **Solar Renewable Energy Credits (SREC)** – allow sale of "green attributes" of solar to someone else
- Market Price. Ceiling set by the ACP or utility cost to build their own facilities. ACP adjusted annually by CPI.
- 1 SREC = 1 MWh = 1,000 kWh = annual production of 1 kW of system size
- Price and terms vary - $200 - $350 per SREC 2 – 5 year contract

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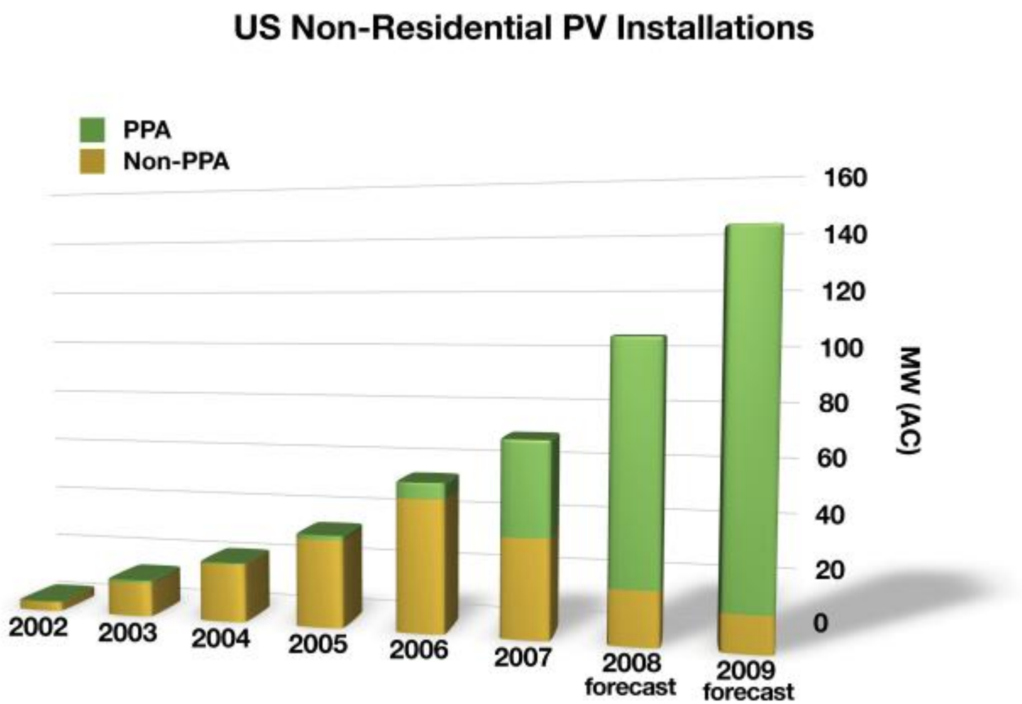
PPA – Power Purchase Agreements

A new model for solar deployment – SAS- "Solar As Service". More than ½ of 2008 CA projects based on the PPA approach. Instead of investing in a solar plant, a customer just agrees to provide access to the roof and promises to buy power at a set rate and term.



PPA – Power Purchase Agreements

•Project developed and owned by third party – energy metered and sold to building customer at agreed upon rate (typically near current market price plus 1-5% escalator). Term 7-20+ years.

•Operating and maintenance risk borne by developer (along with grant, ITC, MACRS and SRECs)

•High transaction (legal) costs limit model to larger projects.

•Developer's investors often have stringent requirements.

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Financial design as important as technical design

- To serve our customers' best interests we must develop a "right-sized" project. (Factors: tax appetite, energy usage, projected rate inflation, cost of financing and customer balance sheet concerns)
- The "instinctual" years-till-breakeven approach is a poor analysis that fails to capture energy inflation or multi-year depreciation subsidies.
- Complex modeling tools provide detailed financial analysis. A full feasibility study requires a complete 25 year pro-forma.
- We often work with the client's financial team to run various scenarios for comparison. (different sizes, with and without financing, conservative VS aggressive inflation assumptions etc)

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Incentives and technology relationship:

•Many worry about investing now or waiting for a price drop.

•Incentives are designed to drop along with costs!

•State has already reduced residential grant as the federal tax credit cap came off.

•SB 221 structured to go down over time

Conclusion: **If the deal makes sense now – do it.** As energy costs go up you are still covered. More like a conventional power plant than a computer.

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Levelized Cost of Energy

LCE = Net Cost divided by lifetime energy production

Provides $/kWh

Susceptible to Rosy Futures

Need to know:

- Lifetime – Warranty or guesstimate?
- Energy production – DC-AC derate, orientation, shading
- Solar calculator – PV Watts, RetScreen, other?
- Technology - thin film produces 0% - 15% more kWh/kW than crystalline
- Module degradation rate ~ .75%/year Xstal, ~1%/year thin film
- O & M and inverter replacement?
- Long term prospects of module supply company

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Solar Case Studies

Akron Metro Transit Center

Institutional Solar

131 kW

$1.1 million

State rebate of $150,000

Grid tied
Flat Roof non-penetrating mounting system

In 2008 the City of Akron began construction on their new transit facility, and decided to go for a LEED Gold rating. The facility, which serves 4,000 Metro riders a day as well as hundreds of Greyhound passengers, is an environmentally friendly structure which includes the largest roof mounted solar array in Ohio, installed by Third Sun. The array should provide about 33% of the building's power. Other green features are a geothermal system, insulated glass, on-site use of rainwater for restrooms and landscaping and recycling of 80% of construction waste.

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Holzer Clinic Athens

Commercial Solar
43 kW
$288,000
$152,000 after state rebate

Grid tied
Flat Roof non-penetrating mounting system

Holzer Clinic Athens built their new 68,000 square foot facility in 2008 to better serve the Athens area and offer cutting edge diagnostic technology. Including a solar power system is also a cutting edge addition to the building. The solar array sits on the flat roof next to a garden area where patients and visitors can get some fresh air and drink coffee from the local café. The array is a Sunpower system, which is comprised of Sunpower solar panels on a T10 non-penetrating racking system. The 6 inverters are located in a utility room just below the array and connect directly into the building to offset power use.

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Findlay Market

Solar on historic 150 year old market house

Duke Energy Sponsored Project   22kW PV produces 26,000kWh/year

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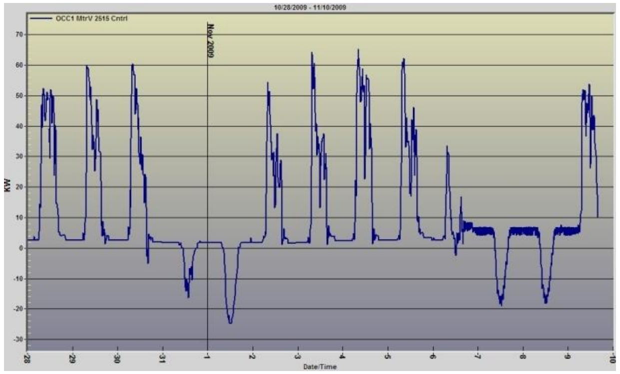
Checco Residence: 5kW PV

Doran Manufacturing

- Energy Efficiency Upgrades
- Demand Management
- 45kW PV solar

Meter spins backward on weekends



Light manufacturing facility with limited roof space spread across multiple levels with numerous roof obstructions and shading issues.

Goal of producing maximum power per square foot drove use of premium efficiency modules to make best use of available space and preserve usable space for future solar installations.

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THANK YOU

Resources:

www.third-sun.com

www.ASES.org

www.PVWatts.org

www.DSIREUSA.org

www.SEIA.org

www.greenenergyohio.org

www.solarprofessional.com